Climate Prediction for Climate Services: How the IPCC Got Involved in Verifying the Climate Information

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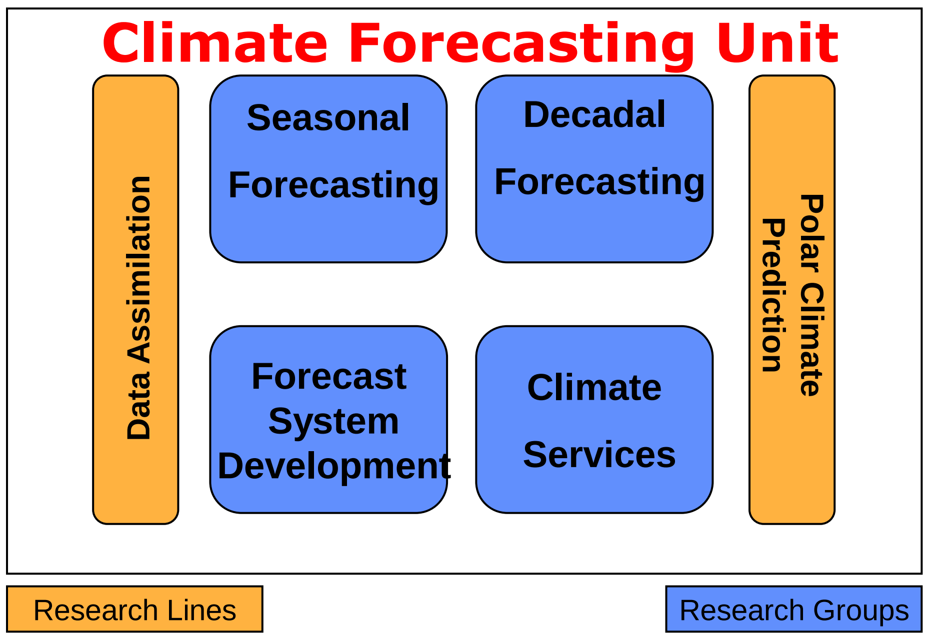
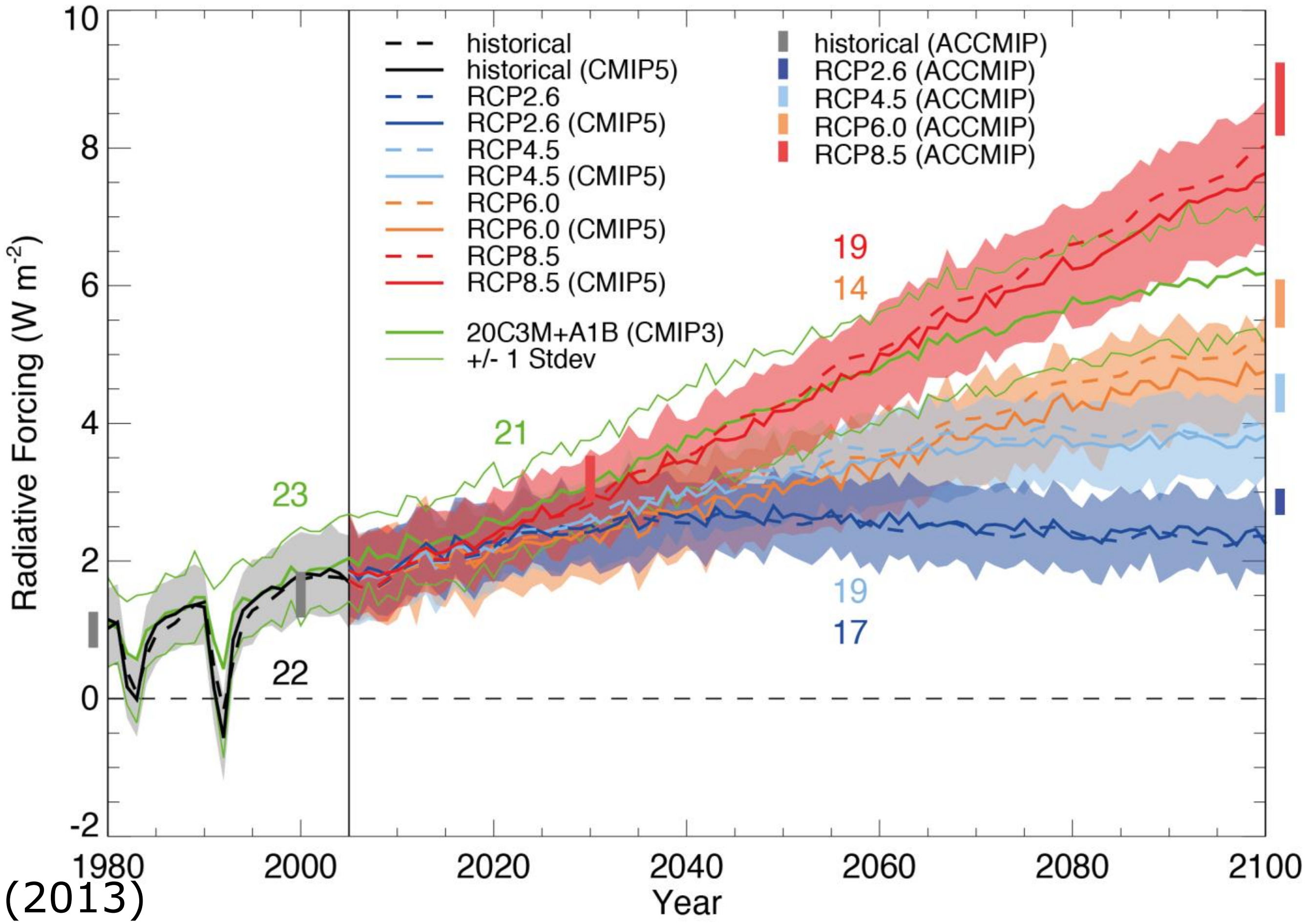


Radiative forcing in climate change

Global mean radiative forcing (Wm^{-2}, dashed) and effective radiative forcing (solid) between 1980 and 2100 with 1850 as baseline.

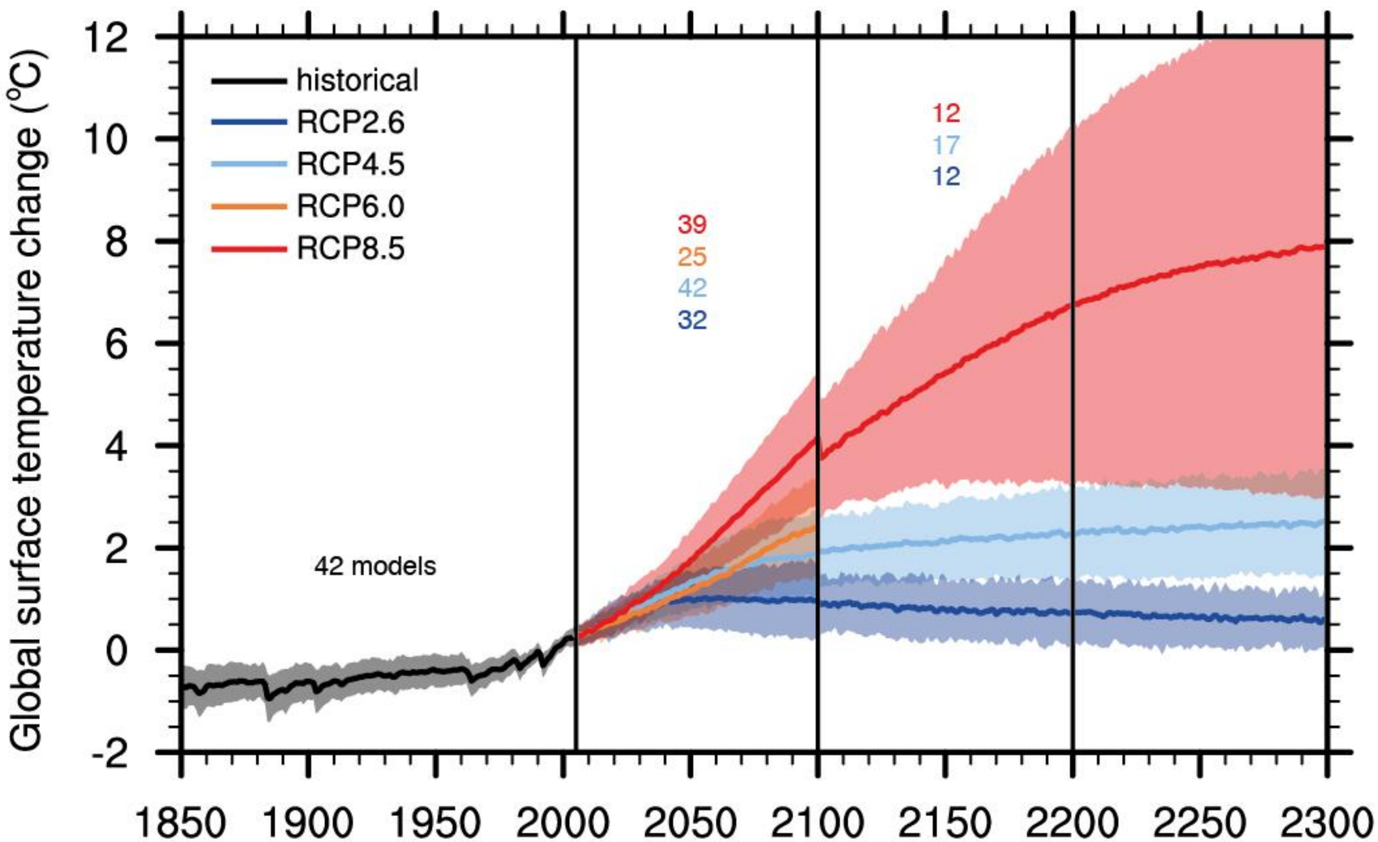
There is little difference between the RCPs.



IPCC AR5 WGI (2013)

CMIP5 projections

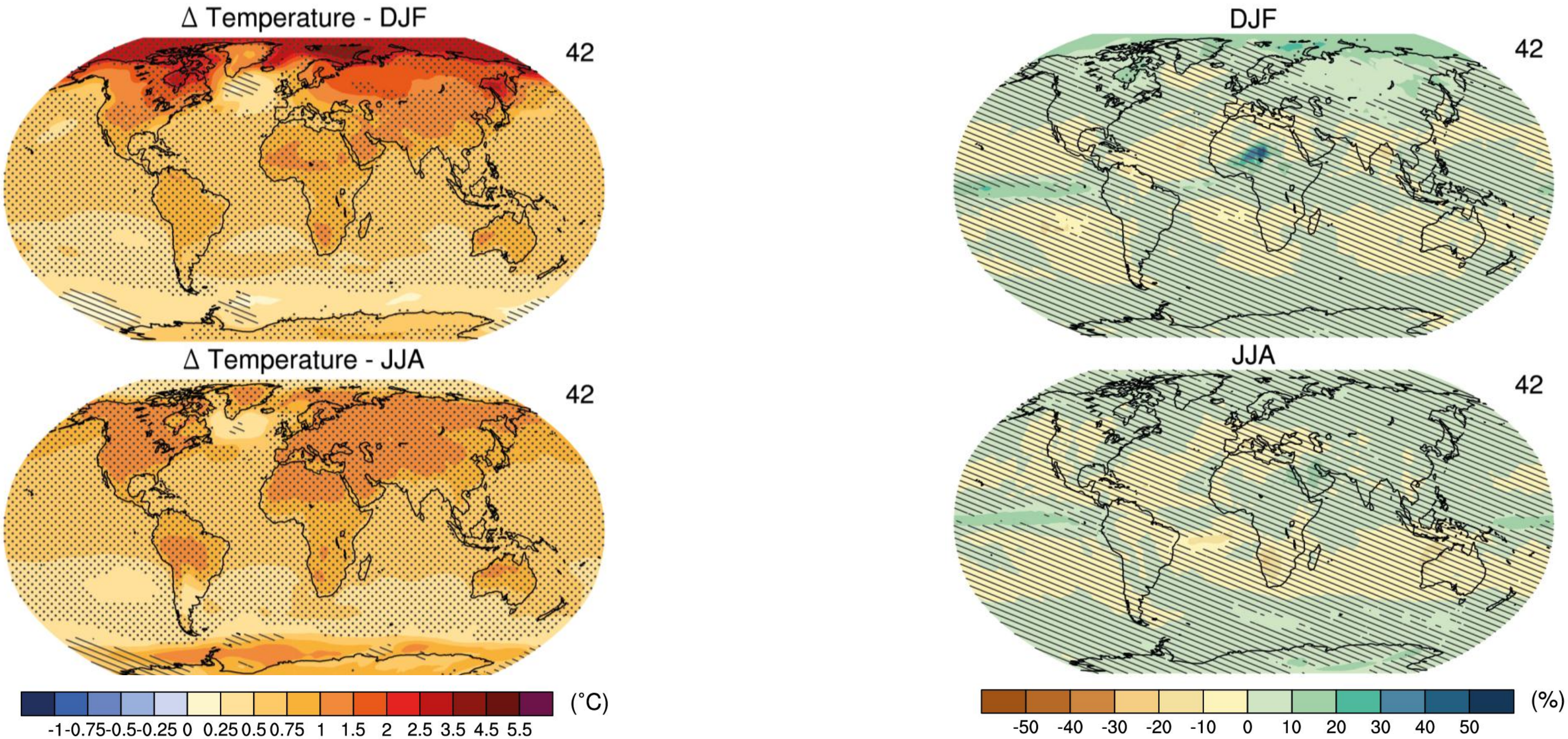
Time series of global annual mean surface air temperature anomalies (relative to 1986–2005) from CMIP5 concentration-driven experiments.



IPCC AR5 WGI (2013)

CMIP5 near-term projections

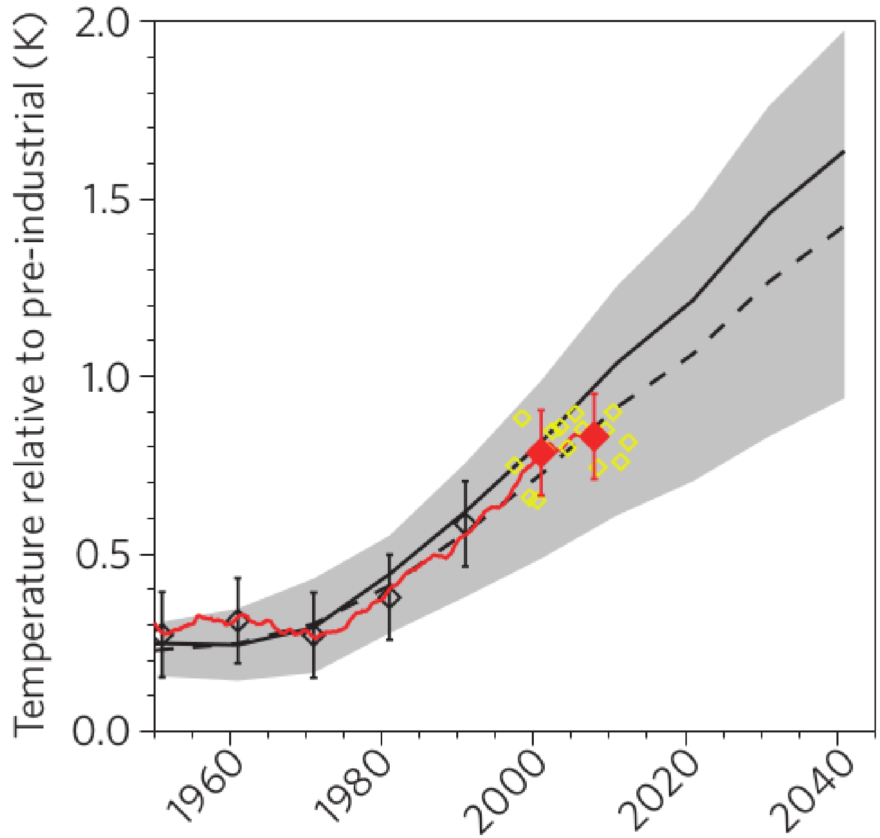
Seasonal-mean air temperature and percentage precipitation change for the RCP4.5 scenario over 2016-2035 (wrt 1986-2005). Stippling for significant changes, hatching for non-significant.



IPCC AR5 WGI (2013)

CMIP5 near-term projections: verification

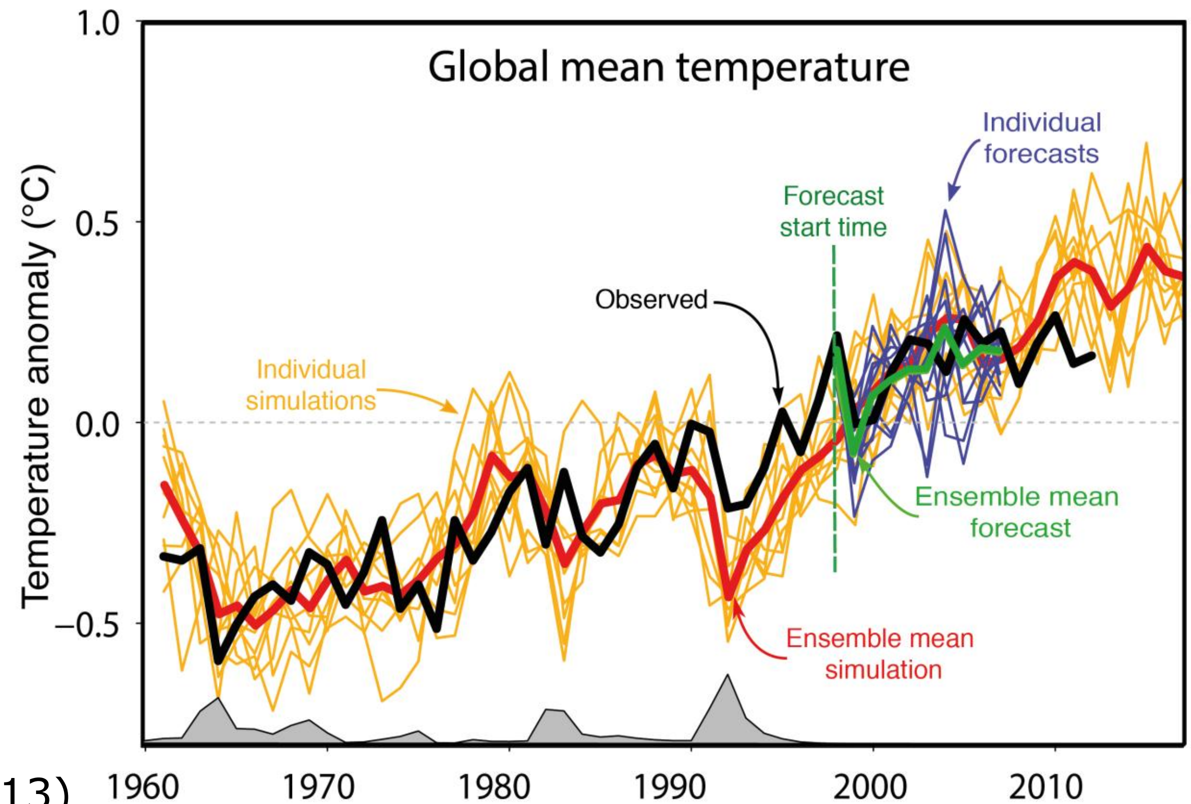
Time series of global-mean decadal mean surface temperature anomalies (relative to preindustrial conditions) from CMIP3 experiments (black solid), after pattern scaling (black dashed) and observations (diamonds). Yellow diamonds for annual observations.



Allen et al. (2013)

CMIP5 simulations

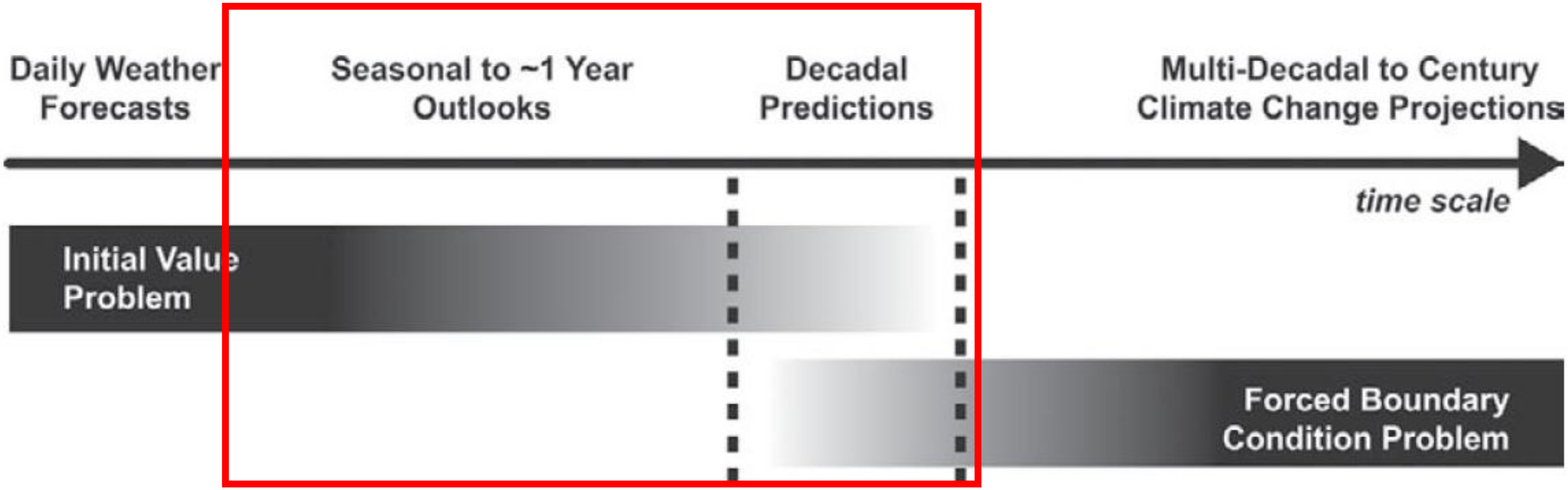
Time series of global-mean annual mean surface air temperature anomalies (relative to 1986–2005) from CMIP5 simulations (yellow lines). An ensemble of forecasts of global annual mean temperature initialized in 1998 is plotted as thin purple lines (average, green line). The grey areas along the axis indicate the presence of external forcing associated with volcanoes.



IPCC AR5 WGI (2013)

Climate prediction

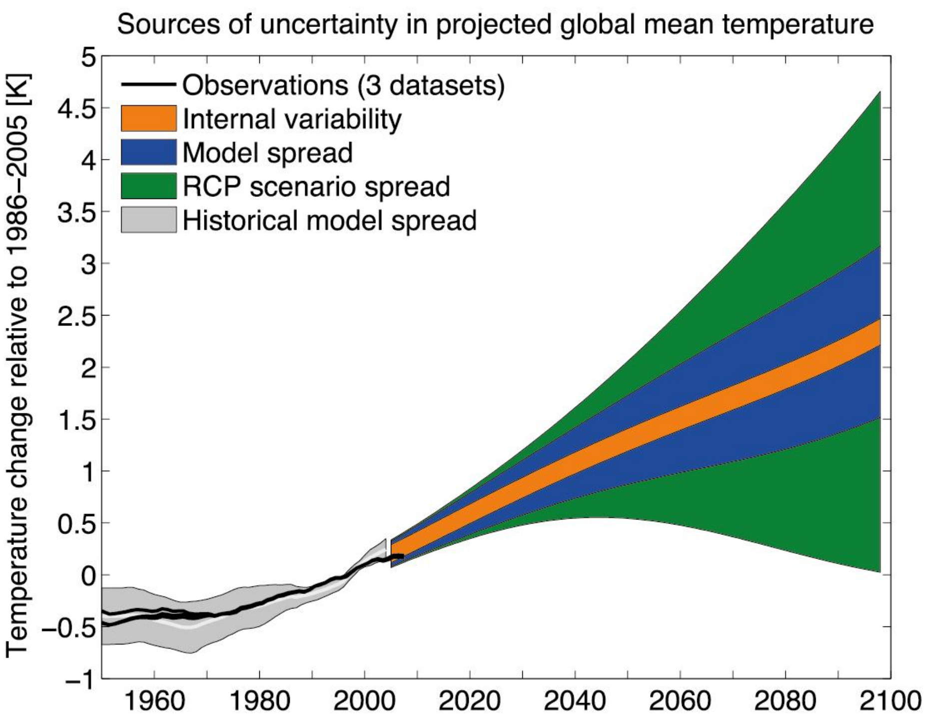
Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialisation and systematic comparison with a simultaneous reference.

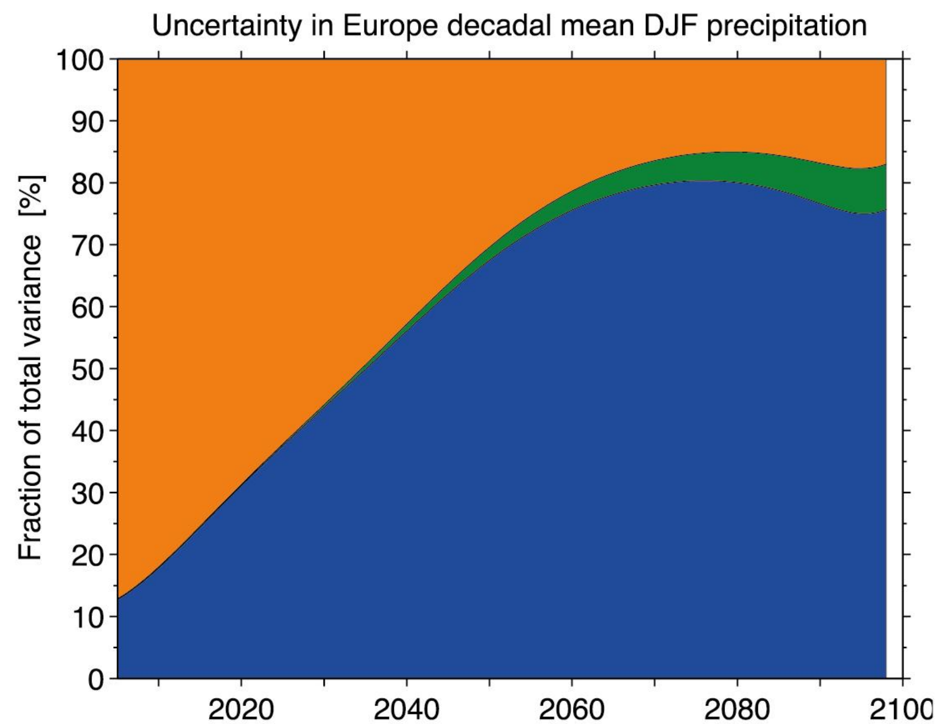


Meehl et al. (2009)

The hope to predict

The sources of uncertainty include the internal variability, model differences and scenario spread. The internal variability is an uncertainty source particularly important for the near term that could be reduced, especially at regional scales.

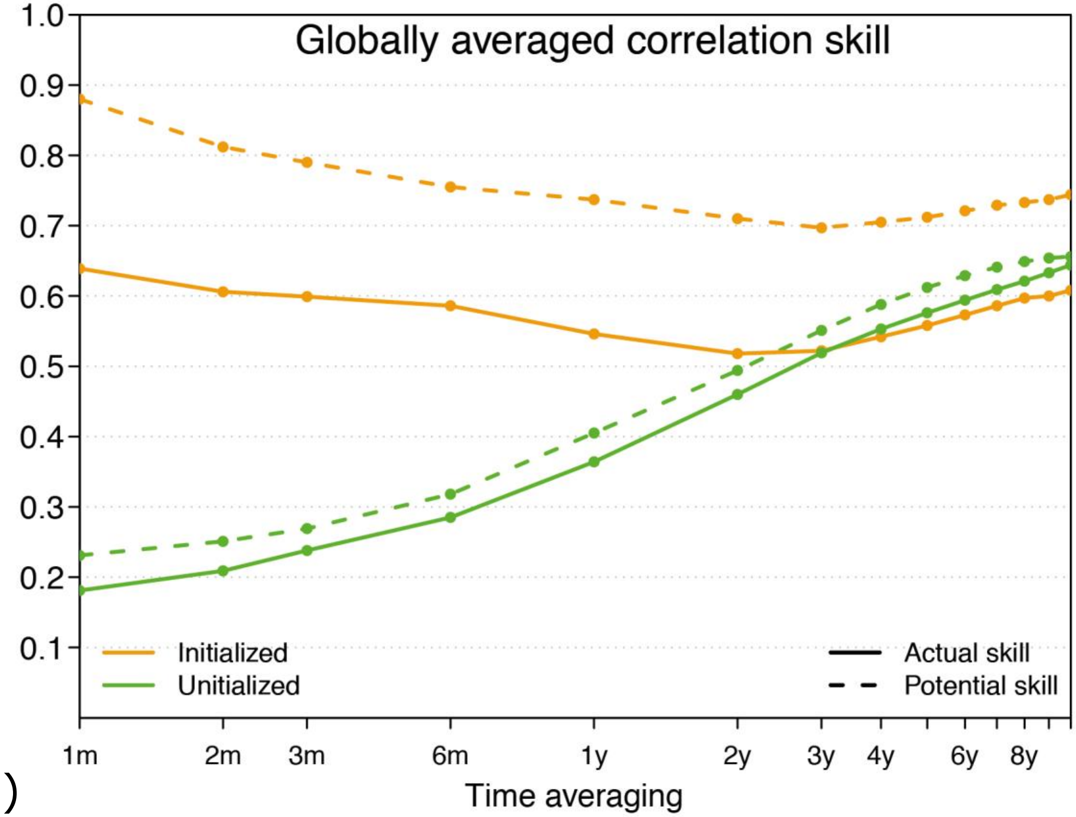




IPCC AR5 WGI (2013)

The hope to predict

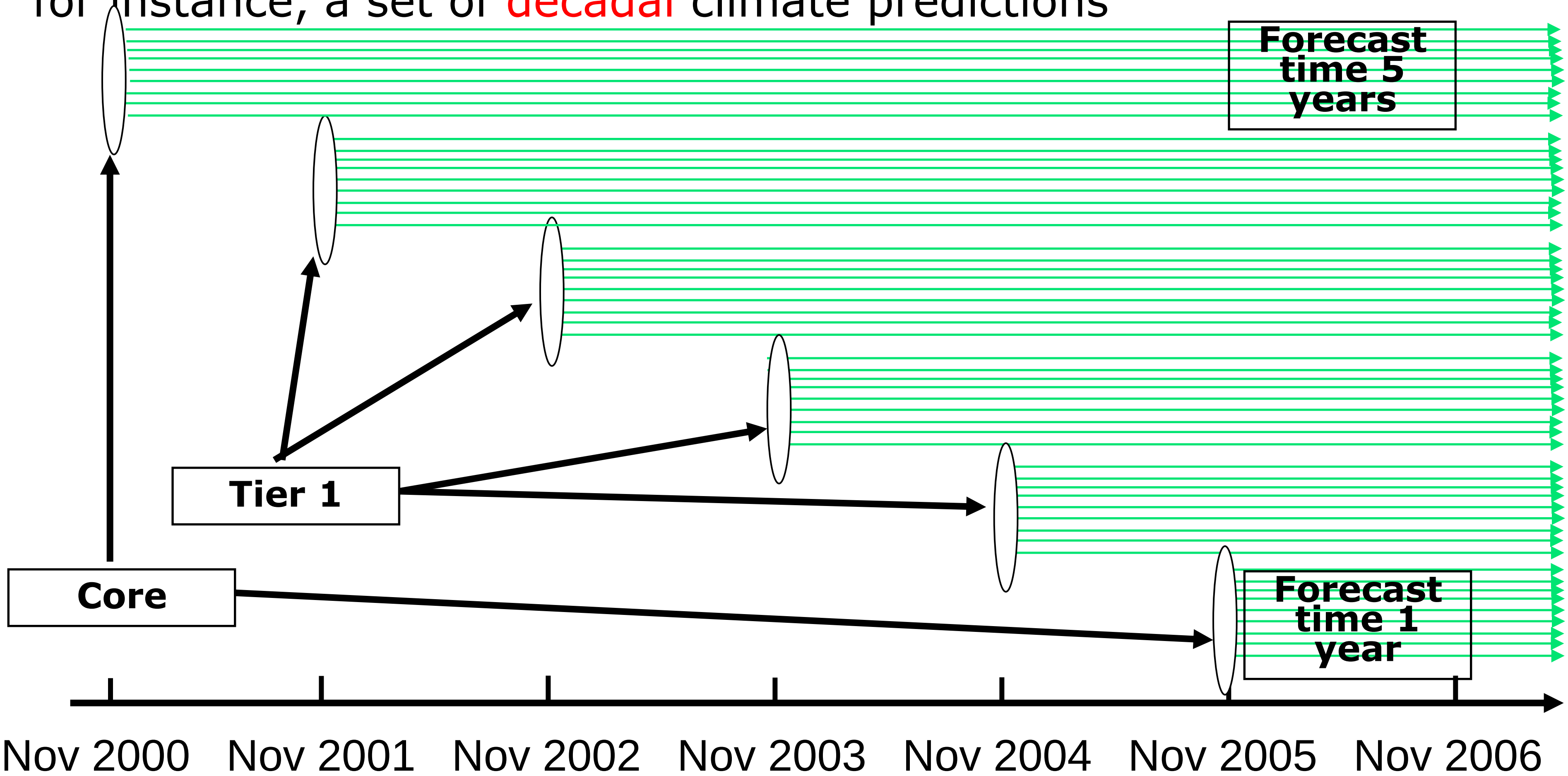
Global average of the grid-point correlation of the ensemble mean of temperature for initialised forecasts (solid orange lines) and the corresponding predictability measure (dashed orange). The equivalent estimates are shown in green for the uninitialised simulations. Results are for averages over periods from a month to a decade.



IPCC AR5 WGI (2013)

Climate predictions

Assume an ensemble forecast system with an initialized ESM to perform, for instance, a set of decadal climate predictions



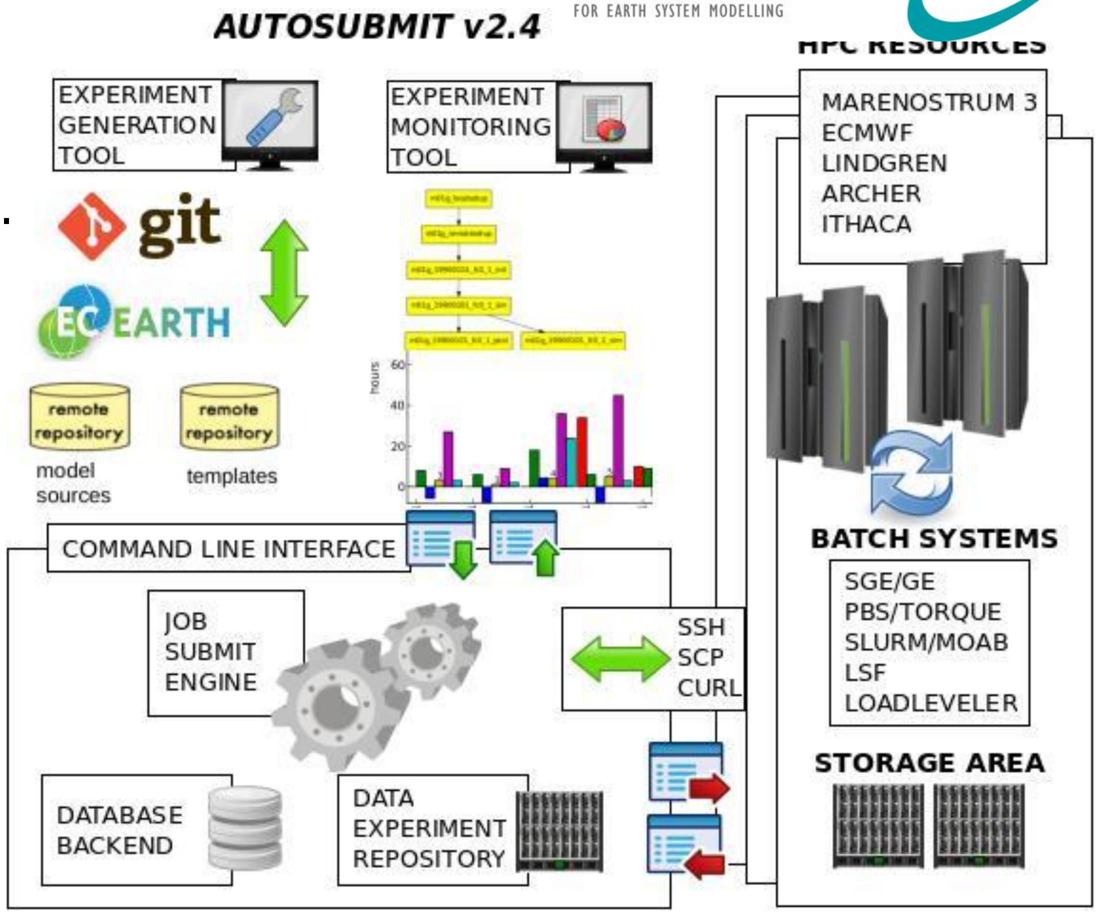
Predictions are also made with empirical forecast systems to be used as benchmarks and to detect untapped sources of predictability.

Autosubmit

Autosubmit acts as a wrapper to run a climate experiment on a HPC. The experiment is a sequence of jobs that it submits, manages and monitors. When a job is complete, the next one can be executed.

- Divided in 3 phases: ExpID assign, experiment creation (including access to a GIT repository), run.
- Separation experiment/autosubmit codes.
- Config files for autosubmit and experiment.
- Database for experiment information.
- Common templates for all platforms.
- Fault tolerance, recovery after crashes.
- Dealing with a list of schedulers and communication protocols.
- Automatic run statistics.

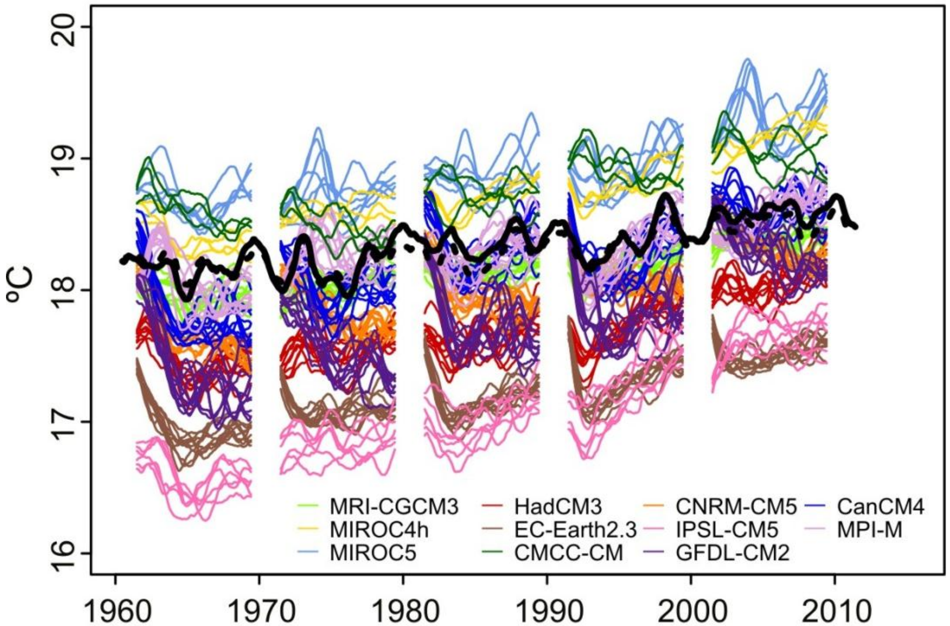
Each job has a colour in the monitoring tool: yellow=completed, green=running, blue=pending, etc.

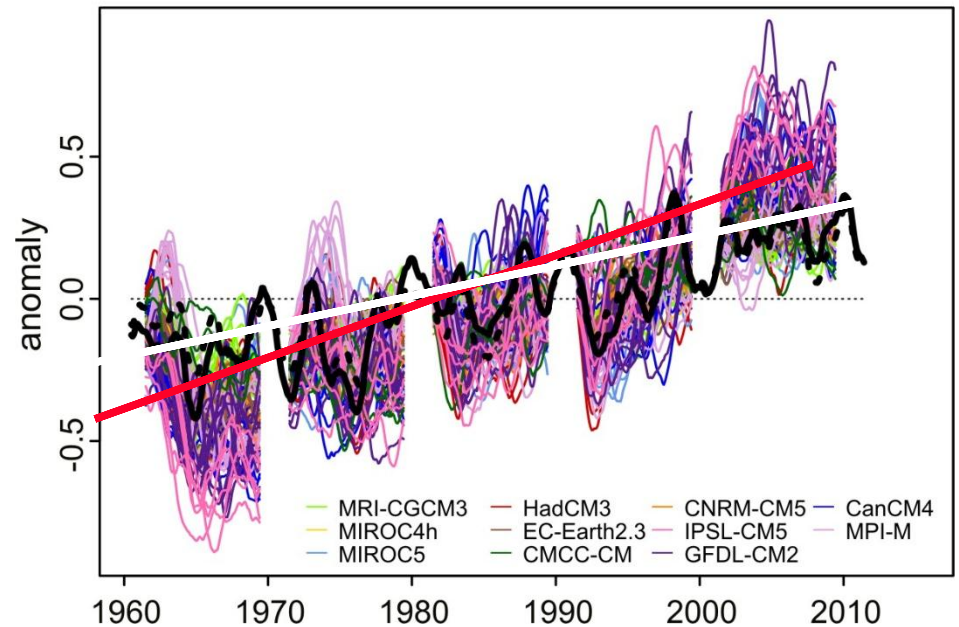


Shock, drift and systematic error

Global mean near-surface air temperature over the ocean (*one-year running mean applied*) from the CMIP5 hindcasts. Each system is shown with a different colour. NCEP and ERA40/Int used as reference.

The systematic error is very different from one system to another.

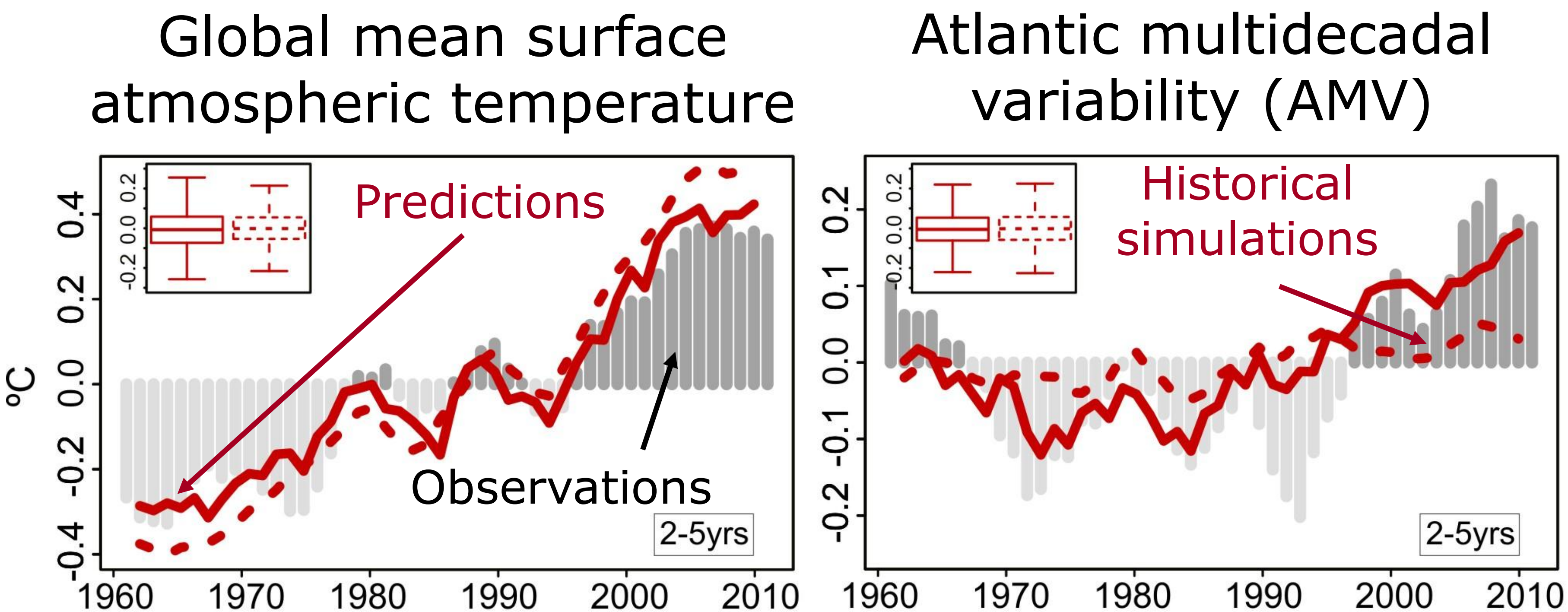




IPCC AR5 WGI (2013)

CMIP5 decadal predictions

CMIP5 decadal predictions. Global-mean t2m and AMV against GHCN/ERSST3b for forecast years 2-5. **The initialised experiments reproduce the GMST trends and the AMV variability and suggest that initialisation corrects the forced model trend and phases in some of the internal variability.**



Doblas-Reyes et al. (2013)

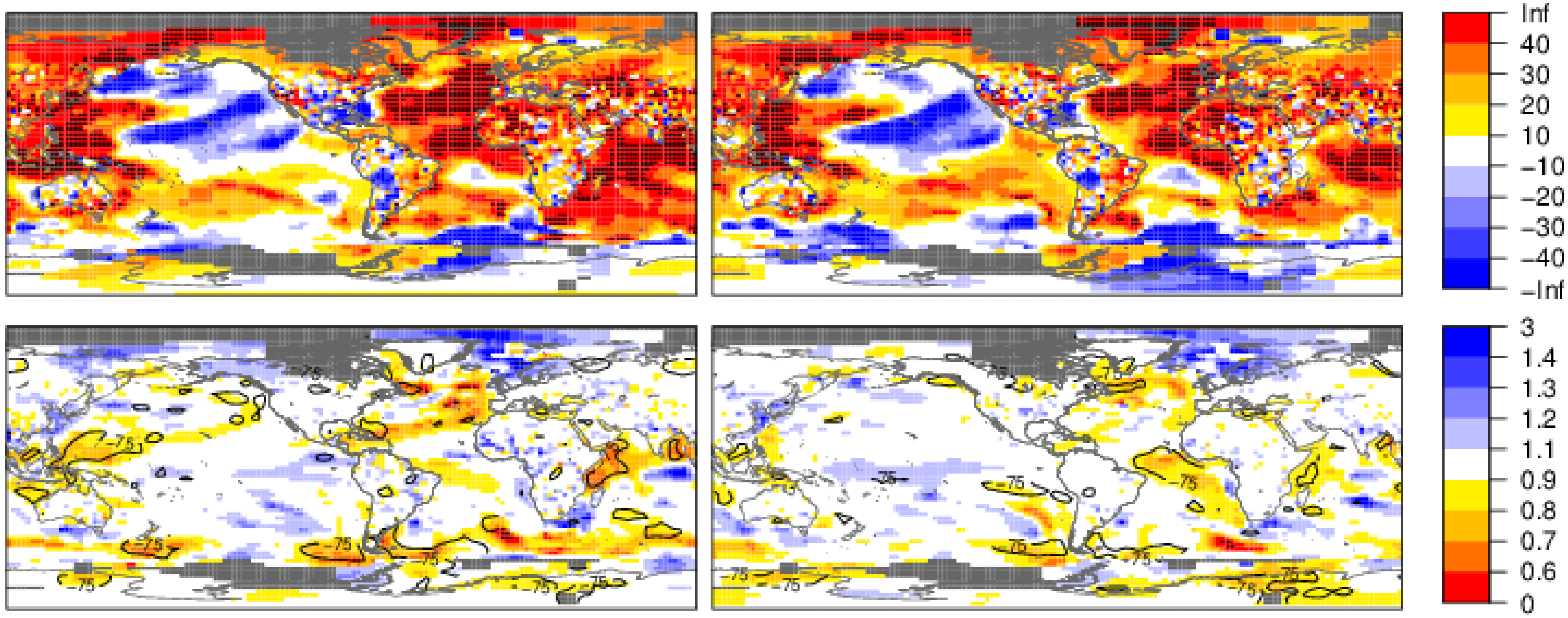
Impact of initialisation in CMIP5

(Top row) Root mean square skill score (RMSSS) of the ensemble mean of the initialised predictions and (bottom row) ratio of the root mean square error (RMSE) of the initialised and uninitialised predictions for the near-surface temperature from the multi-model CMIP5 experiment (1960-2005) for (left) 2-5 and (right) 6-9 forecast years. Five-year start date interval.

Forecast year 2-5 | **Forecast year 6-9**

Init RMSSS of ensemble mean

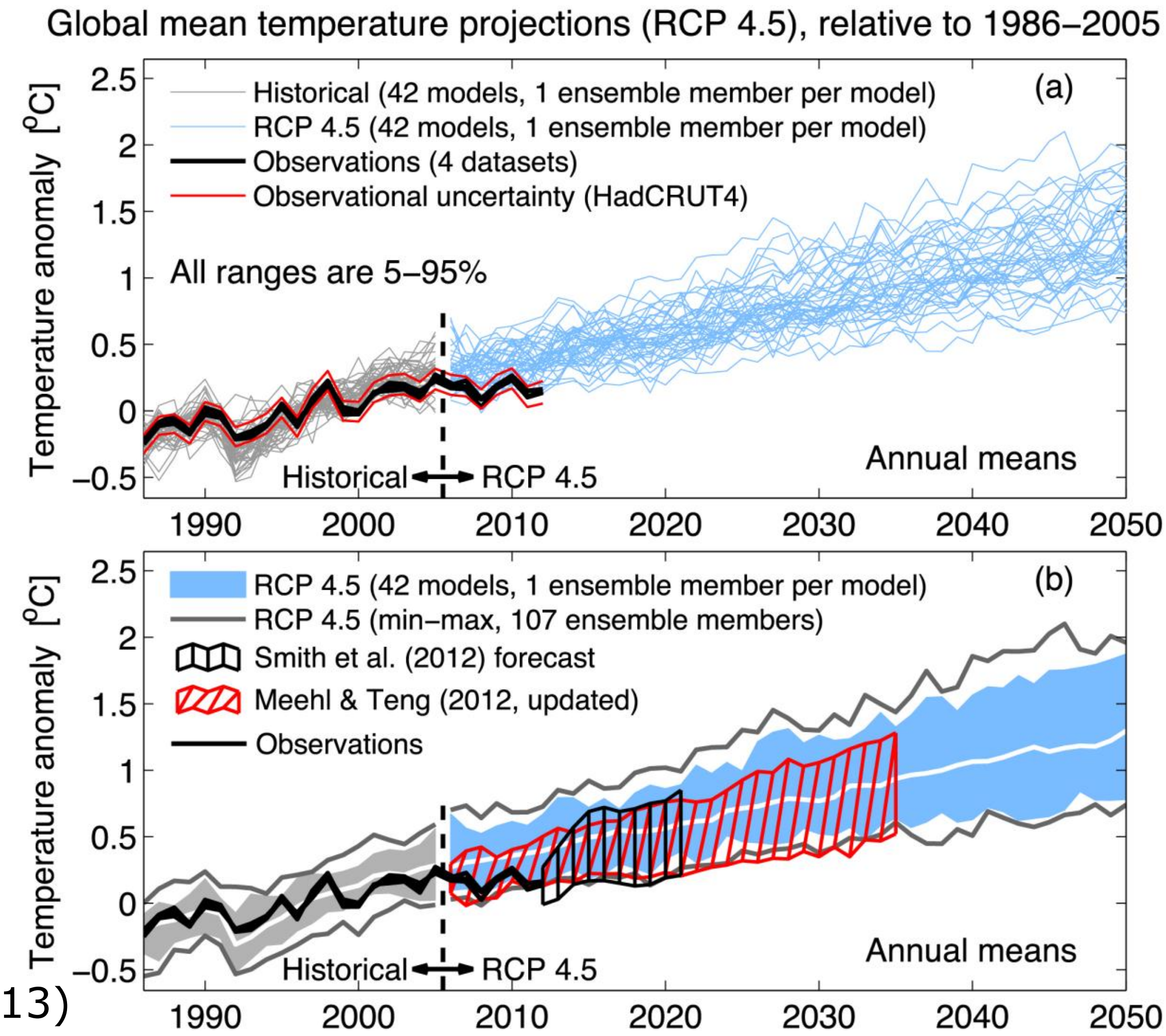
Ratio RMSE Init/NoInit



Doblas-Reyes et al. (2013)

CMIP5 predictions and projections

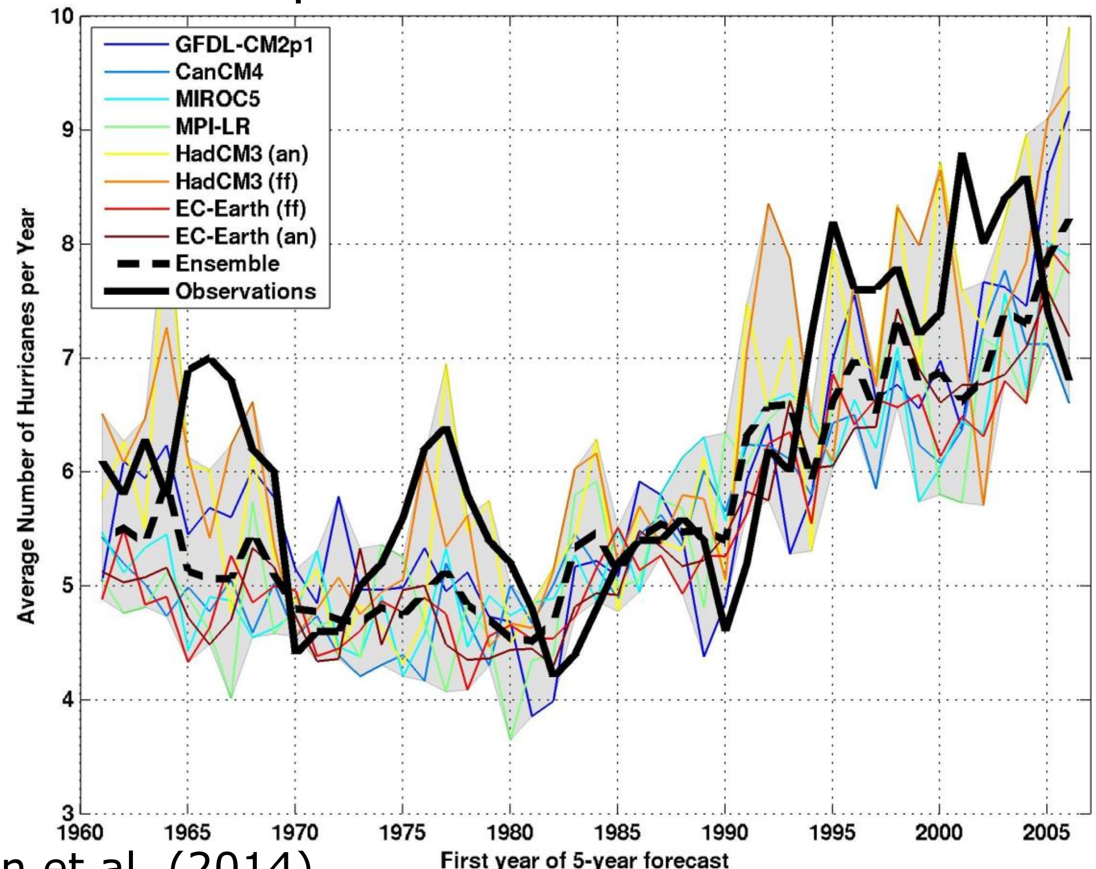
Annual-mean global-mean temperature predictions and projections from CMIP5.

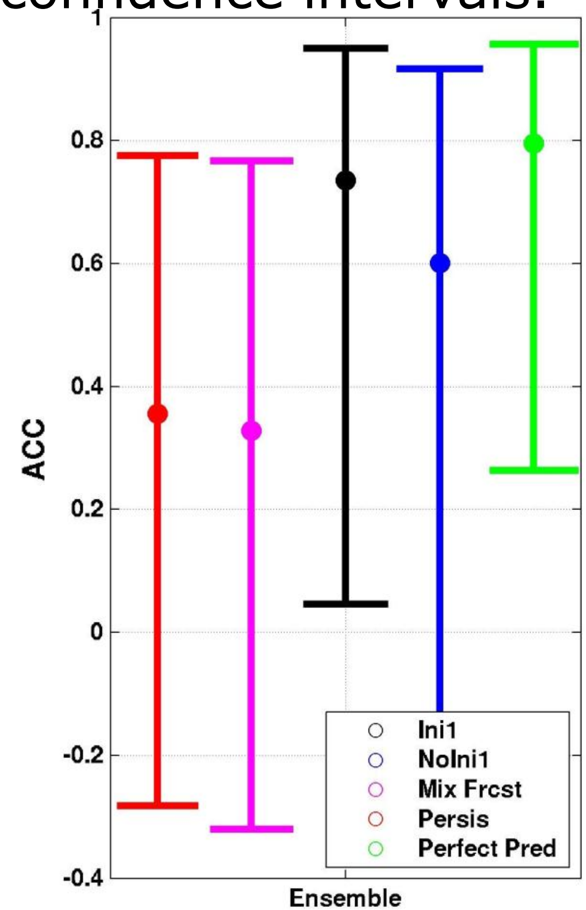


IPCC AR5 WGI (2013)

Hurricane frequency prediction

Average number of hurricanes per year estimated from observations and from the CMIP5 multi-model decadal prediction ensemble (forecast years 1-5). The correlation of the ensemble mean for the initialized, uninitialized and statistical predictions are shown with the 95% confidence intervals.

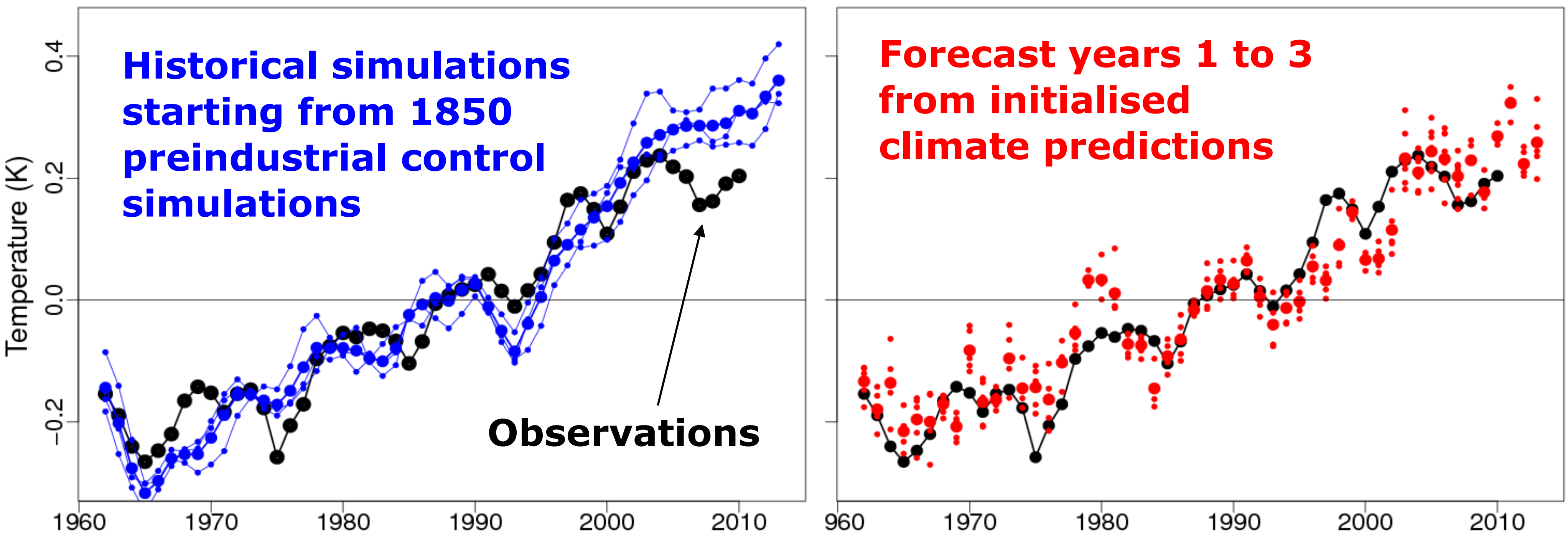




Caron et al. (2014)

Attribution of the XXIst century hiatus

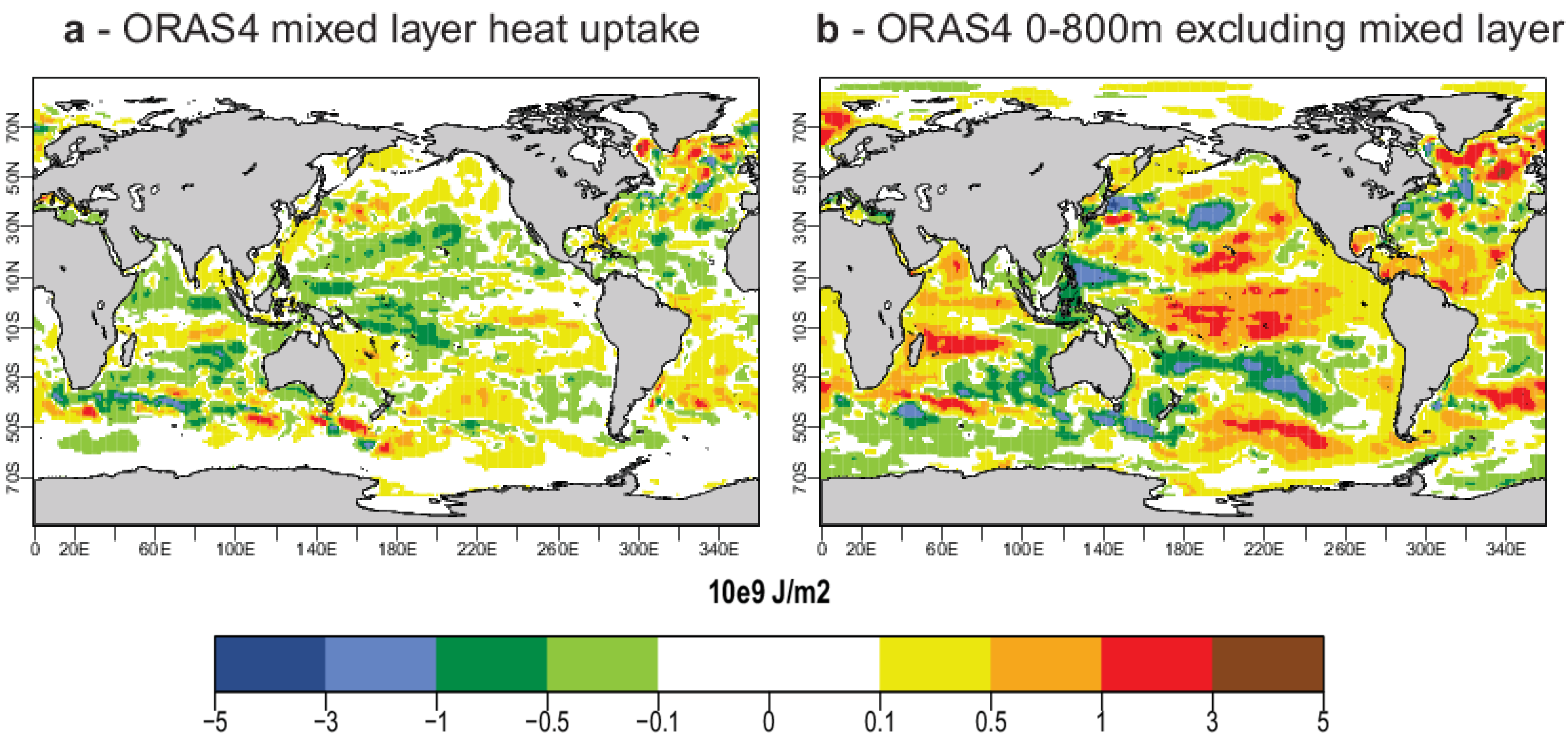
Predictions of the recent global-temperature slow down with EC-Earth 2.3. Global-mean SST from observations (ERSST) and simulations, three-year averages. The experiments suggest an important role of the internal variability, especially the oceans, in the hiatus.



Guemas et al. (2013)

Hiatus in the ocean

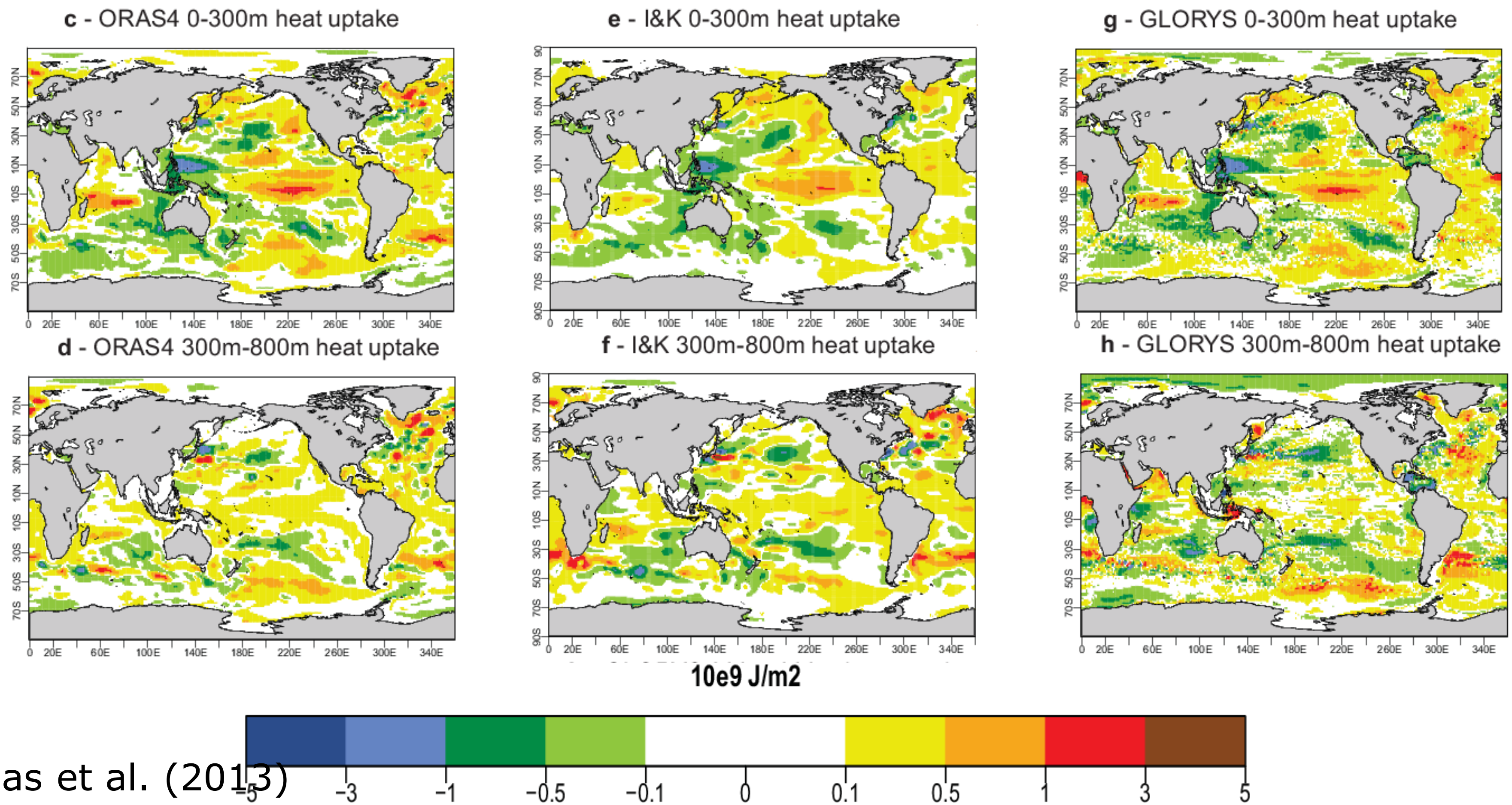
Ocean heat uptake computed as the average of the differences over the periods (2001,2003)-(1998-2000), (2002,2004)-(1999,2001) and (2003,2005)-(2000,2002) from the ORAS4 ocean reanalysis.



Guemas et al. (2013)

Hiatus in the ocean

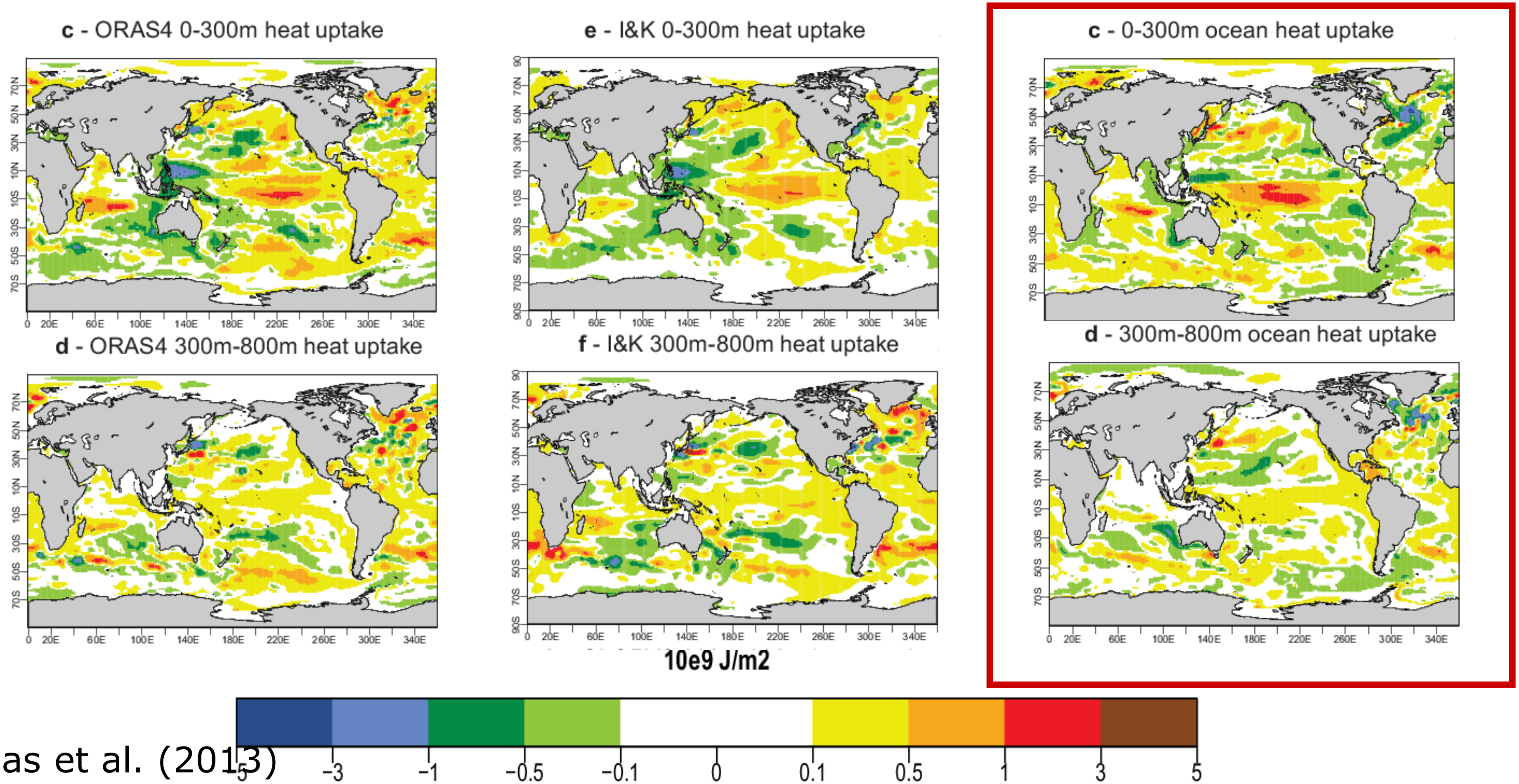
Ocean heat uptake computed as the average of the differences over the periods (2001,2003)-(1998-2000), (2002,2004)-(1999,2001) and (2003,2005)-(2000,2002) for two ocean layers and three reanalyses.



Guemas et al. (2013)

Hiatus in the ocean

Ocean heat uptake as the average of differences over (2001,2003)-(1998-2000), (2002,2004)-(1999,2001) and (2003,2005)-(2000,2002) for two ocean layers, two reanalyses and the EC-Earth2.3 2-4 year predictions.



Guemas et al. (2013)

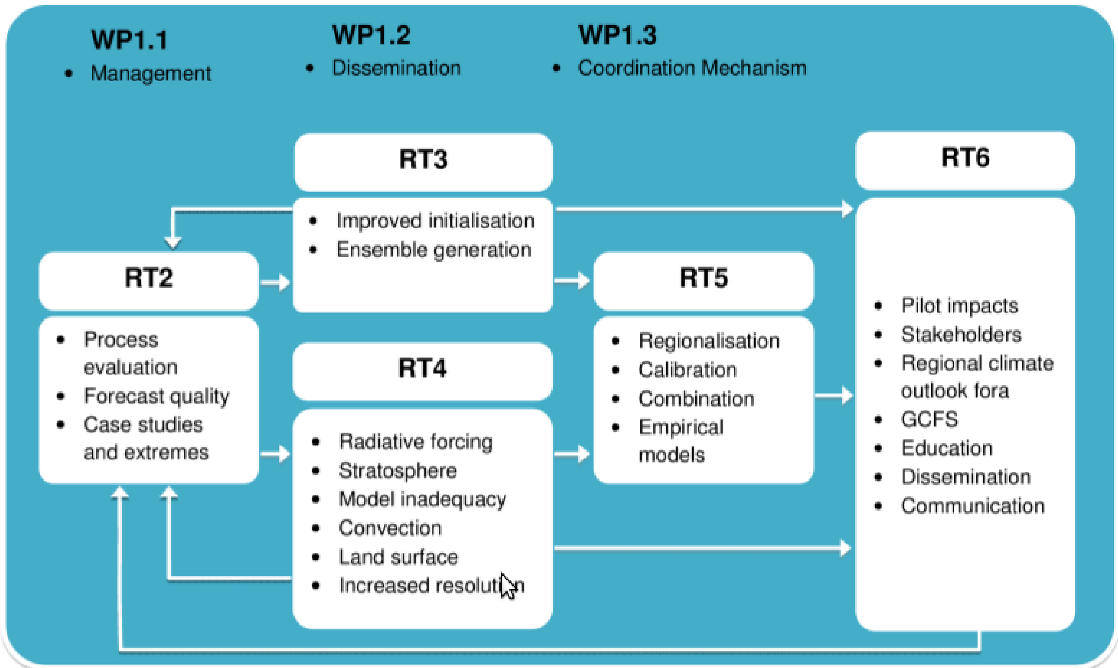
Some open fronts

- Work on initialisation: initial conditions for all components (including better ocean), better ensemble generation, etc. Link to observational and reanalysis efforts.
- Model improvement: leverage knowledge and resources from modelling at other time scales, drift reduction. More efficient codes and adequate computing resources.
- Calibration and combination: empirical prediction (better use of current benchmarks), local knowledge.
- Forecast quality assessment: scores closer to the user, reliability as a main target, process-based verification.
- Improving physical processes: sea ice, projections of volcanic and anthropogenic aerosols, vegetation/land, …
- More sensitivity to the users' needs: going beyond downscaling, better documentation (e.g. use the IPCC language), demonstration of value and outreach.

SPECS FP7, overall strategy

SPECS will deliver *a new generation of European climate forecast systems, including initialised Earth System Models (ESMs) and efficient regionalisation tools to produce quasi-operational and actionable local climate information over land at seasonal-to-decadal time scales with improved forecast quality and a focus on extreme climate events, and provide an enhanced communication protocol and services to satisfy the climate information needs of a wide range of public and private stakeholders*.

Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, IC3, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniHH
UM	UKMET



WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

Towards CMIP6

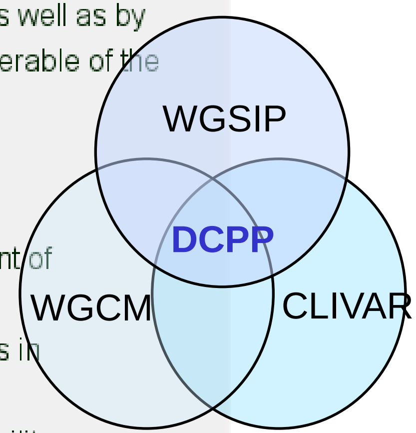
The Decadal Climate Prediction Panel (DCPP) promotes coordinated decadal prediction experimental set ups and informal near-real time exchange of multi-model forecasts. It also organises the decadal MIP towards CMIP6 (with four components, and including consideration of a transpose CMIP).

The DCPP is managed by WGSIP, WGCM and CLIVAR; chair George Boer.

The term "decadal prediction" encompasses predictions on annual, multi-annual to decadal timescales. The possibility of making skilful forecasts on these timescales, and the ability to do so, is investigated by means of predictability studies and retrospective predictions (hindcasts) made using the current generation of climate models as well as by means of statistical approaches. Skilful decadal prediction of relevant climate parameters is a Key Deliverable of the WCRP's Grand Challenge of providing Regional Climate Information.

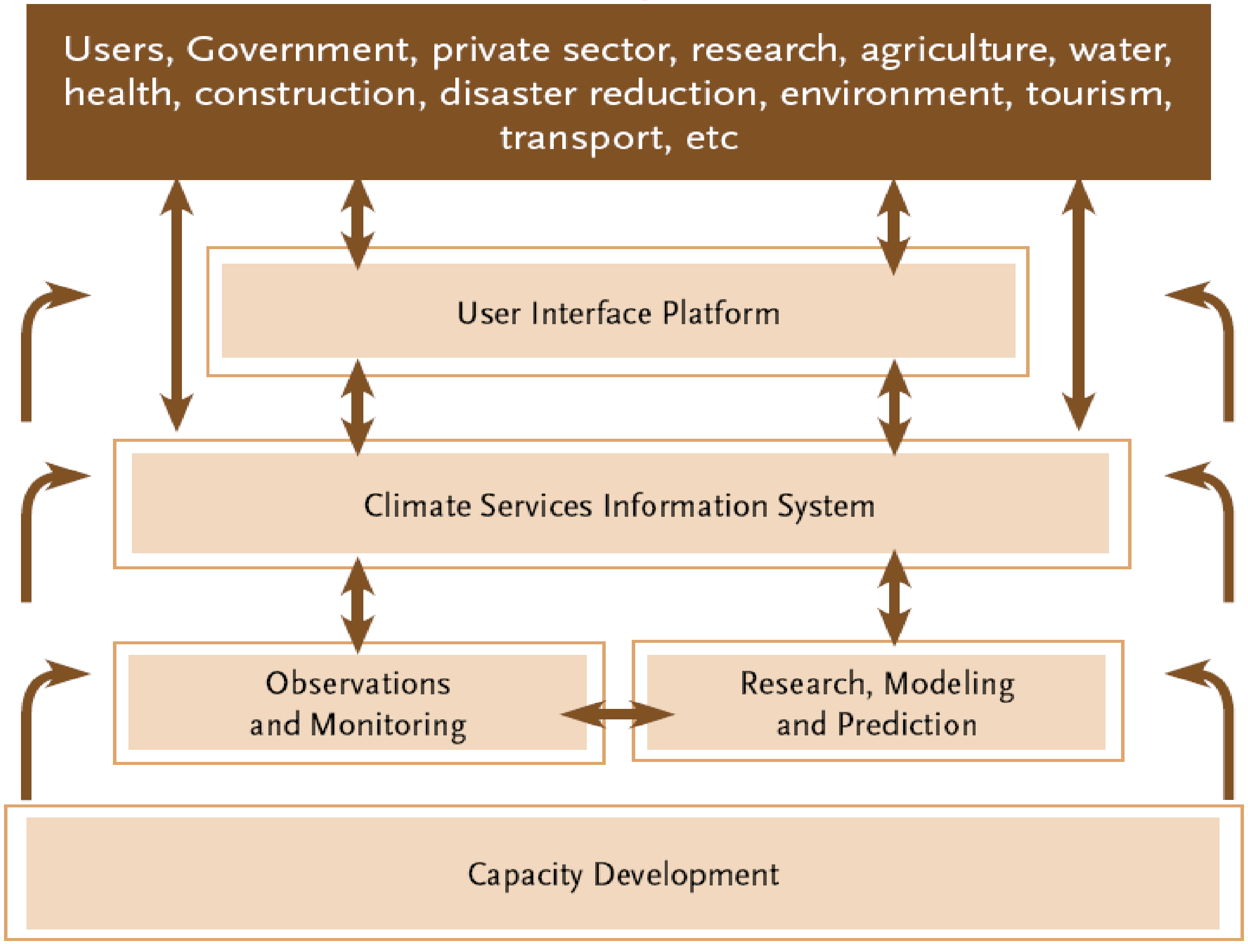
The DCPP envisions four components:

- ***Hindcasts***: the design and organization of a coordinated decadal prediction (hindcast) component of CMIP6 in conjunction with the seasonal prediction and climate modelling communities
- ***Forecasts***: the ongoing production of experimental quasi-operational decadal climate predictions in support of multi-model annual to decadal forecasting and the application of the forecasts
- ***Predictability and mechanisms***: the organization and coordination of decadal climate predictability studies including the study of the mechanisms that determine predictability
- ***Case studies***: the organization and coordination of case studies to investigate the ability to predict particular climate shifts and variations that have occurred and to identify the processes determining these behaviours



How to proceed with all this?

Global Framework for Climate Services (GFCS): using climate predictions as a new adaptation tool. Climate Services focus on the transformation of climate-related data into customized products.



Climate services

The five requirements for climate services to be relevant:

- A true climate services function to enable effective responses: services function if there is a significant link between climate and human/eco systems.
- The ability to anticipate makes knowledge powerful. Bring the forecasting discipline to a wider family of products.
- The coupling of the physical sciences, human dimensions and impact sciences is rarely co-located in institutions or funding agencies.
- There is a need to tackle the issue of scale and the demand for an integrated approach.
- Evolve from independent climate services and modeling efforts to environmental intelligence" centres with vigorous connection with users and decision makers.

Some of the things badly missing

- Better understanding of the impact models, and the best way to adapt them to the useful climate information available
- Bias correction, calibration and combination
- Downscaling, when necessary
- Documentation (some stakeholders are used to the IPCC calibrated language, which is different to the climate forecasting language), demonstration of value and outreach
- The EUPORIAS FP7 project, working alongside the SPECS project, is considering solutions to address some of these problems.

EUPORIAS: prototypes

- EUPORIAS intends to maximise the societal benefit of climate prediction technologies and, hence, increase the resilience of European society to climate change by demonstrating how climate information becomes usable.
- A set of prototypes, examples of a climate service for s2d time scales in Europe, are the main project outcome.
- Six proposals selected by an external panel based on value to the users, skill in the predictions, stakeholder engagement, robustness of the impact model:
  - Outlook for UK winter conditions to inform transport industry
  - Food security in East Africa for WFP
  - Winter land management for Clinton Devon Estate
  - Renewable energy management (RESILIENCE)
  - River management in two French catchment areas
  - Hydroelectric production in Sweden

The wind energy problem

To satisfy the users' requirements for sub-seasonal to seasonal forecast information:

- High-frequency wind forecasts at ~100 metre height
- Bias corrected forecast data, i.e. whose statistical properties mimic those of the data measured at the wind turbine height -> Bias correcting and calibrating high-frequency data is extremely complicated and destroys the little skill available

On top of this:

- Local measurements are not long
- They are not even made available

Adapting impact models

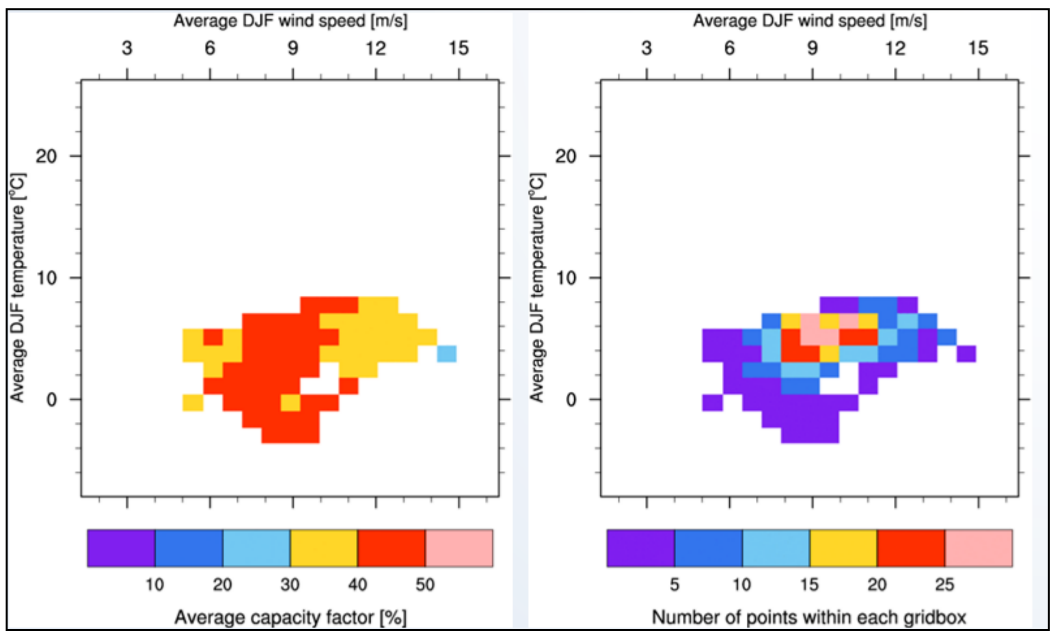
Impact surfaces of a simple wind-energy model over the North Sea for DJF as function of the mean seasonal 10 m wind speed and temperature.

(Left) Capacity factor (average power generated divided by the maximum power of a specific turbine) estimates obtained using the XXth Century Reanalysis, a Rayleigh function to estimate high-frequency winds from mean daily values and a wind profile power law to obtain 100 m winds from 10 m winds. (Right) Frequency of occurrence of each bin.

D. MacLeod (Univ. Oxford)

DJF wind speed (m/s)

DJF temperature (ºC)



It only needs seasonal-average bias-corrected forecast data to make predictions of the capacity factor!

But this is just a small effort

Example of a national energy modelling system.

We have only addressed this part.